Original article

Appropriate waist circumference cut off level for hypertension screening among admission students at Chiang Mai University

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Background There is no official cut off value of waist circumference (WC) measured at the superior iliac crest level (WCI) for health screening young adolescents in Thailand. This study aimed to determine a correlation between WCI and measurements at the midpoint between the lower costal margin and superior iliac crest (WCM), and define appropriate WCI and body mass index (BMI) cut off levels for health screening admission students in northern Thailand.

Methods Students passing the entrance exams for the academic year, 2012, had health screening, which included physical examination, and WC, BMI, and blood pressure (BP) measurements.

Results Of 2,525 students receiving both WCI and WCM measurements, 59.50% were female. Correlation between the WCI and WCM measurements was 0.86, with 5.10% of the students having high BP. The WCM of 90 cm in males and 80 cm in females (WCM9080) was set as the standard for receiver operating characteristics (ROC) analysis of high blood pressure. The WCI of 90 cm in males and 80 cm in females (WCI9080) had significantly larger areas (0.6837) than those of WCM9080 (0.6278). WCI9080 had 44.53% sensitivity, 92.99% specificity, and 90.53% corrected classification.

Conclusions The proposed WCI cut off value was WCI9080. A further cohort study is needed to confirm these values. For national reference, this study recommends measuring at the umbilical level, due to its feasibility. Also, an appropriate cut off level should be determined in the context of the Thai population. **Chiang Mai Medical Journal 2013;52(3-4):57-64.**

Keywords: waist circumference, screening, adolescence, Thailand

Introduction

Body mass index (BMI) and waist circumference (WC) were used for obesity assessment. An elevated BMI is associated with metabolic diseases [1-3]. Children and young adolescents with obesity are more likely to have health problems compared to those with normal weight [4-6]. Populations should have health prevention screening and promotional intervention as early

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as 20 years old [1,7]. Recently, WC measurement has been used as an anthropometric indicator for metabolic diseases. A Korean health survey of a nationally representative sample showed a cut off level as low as 85 cm for men and 80 cm for women for predicting metabolic risk factors [8]. Another Korean study found that the cut off level for discriminating hypertension was 84 cm and 77 cm for men and women, respectively. These values were lower than those recommended by the World Health Organization (WHO) [9]. A study in Japan found that an optimal WC cut off value was 89.8 cm and 82.3 cm for men and women, respectively, which was lower than that currently recommended (women ≥ 90 cm and men ≥ 85 cm) [10]. An increasing visceral fat area with a normal BMI in Asians has been reported [11]. In recent years, other continents and counties in Asia also re-defined the WC cut off level to lower values in their populations [10,12-16].

The cut off level for screening and health education is based on the Thai Ministry of Public Health definition of 90.0 cm and 80.0 cm in males and females, respectively. These values were based on a WC measurement at the midpoint between the lower costal margin and superior iliac crest (WCM), but implemented based on the umbilical level (WCU), due to practical reasons. In addition, different methods of measurement gave differing WC values. WC can be measured also at the superior iliac crest level (WCI) [1,2,17], on which there is no official cut off value for screening young adolescents in Thailand. Chiang Mai University (CMU) was the first regional university in northern Thailand. It has a good reputation and its fame attracts many young adolescents to apply for the entrance examination. Around six thousand students pass the examination each year. The majority of them come from the northern region of Thailand. In the academic year, 2012, the Health Promotion Center at the Faculty of Medicine, CMU, provided health screening for admission students. The staff conducted anthropometry measurements in order to determine the correlation between WCI and WCM and define appropriate WC and BMI cut off levels for health screening.

Methods

Students who passed the CMU entrance examination for the academic year, 2012, were eligible to participate in this study. On their interview date, they were given health screening, which included physical examination and anthropometry measurement (height in centimeters-cm, body weight in kilograms-kg, waist circumference in cm, and blood pressure). High blood pressure (BP) was defined as systolic BP (BPs) when at least 140 millimeter lead (mmHg), and/or diastolic BP (BPd) when at least 90 mmHg. From a total of 6,344 admission students at CMU, about one third from each faculty had their WC measurement taken by utilizing both WCI and WCM methods. Thus, 2,525 students were analyzed. According to the policy of the Thai Ministry of Public Health, overweight and obesity was defined as WCM when it was at least 90 cm in males and 80 cm in females (WCM9080). WCM9080 then became a gold standard for comparing different methods of WC measurement and it was used as the cut off level in this study. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2)[2].

The Ethics Committee of the Faculty of Medicine approved this study (Study code EME-12-1196-EM).

Data analysis

Descriptive analyses included proportion, means ± standard deviation (SD), or median (range) depending on data distribution. Univariate analyses included the Chi-square test, ANOVA, or Kruskal Wallis tests depending on data distribution. An alpha level was set at 0.05. A risk ratio (RR) and 95 percent confidence interval (95% CI: lower - upper) for each factor of interest was calculated. Receiver Operating Characteristics (ROC) analysis, sensitivity, specificity, classification, and likelihood ratio were used in order to determine appropriate anthropometric indicator cut off levels. A Sidak p–value of less than 0.05 was considered significant. Data management and analyses were performed using Epi Info for Windows version 3.5.4 (Centers for Disease Control and Prevention, Atlanta, GA) and STATA version 11 (Statacorp LP. College Station, TX).

Results

A majority of the 2,525 students were female (59.50%), with a mean age of 18.66±0.78 years. The correlation between WCI and WCM was 0.86. High BP was identified in 5.10% of the students.

1. Anthropology measurement

Waist circumference: The median WCM of males and females was 80.00 cm (range: 61.00-

125.00 cm) and 77.00 cm (range: 53.00-132.00 cm), respectively.

Body mass index: The BMI ranged from 17.90 kg/m^2 to 61.30 kg/m^2, with 10.20% and 14.50% of the students having a BMI of between 23.00 kg/m^2 and 24.90 kg/m^2, respectively, and at least 25.00 kg/m^2, subsequently.

2. Relationship between anthropometry indicators and high blood pressure

All Anthropometry indicators had statistically significant association with high BP. The relative risk ranged from about three to nine times (Table 1).

Waist circumference: The median WCM of male (82.0 cm) and female (81.0 cm) students with high BP had statistically higher significance than that of males (72.0 cm) and females (67.00 cm) with normal BP (Table 2).

The median WCI of male (87.0 cm) and female (86.0 cm) students with high BP had statistically higher significance than that in males (79.0 cm) and females (77.00 cm) with normal BP (Table 2).

Body mass index: The higher the BMI cut off level the higher the prevalence of high BP. The prevalence ranged from 0.7% to 28.6% (Table 3).

3. Receiver operating characteristic (ROC) curve

When comparing the area under the ROC curve of high BP, using WCM as a gold standard, WCI and BMI had larger areas than those of WCM, with statistical significance. (Table 4).

Sensitivity, specificity, and corrected classification of anthropometry indicators: The WCI of at least 90 cm in males and at least 85 cm in females had 38.28% sensitivity, 92.49% specificity, and 92.59% corrected classification. The WCI of at least 90 cm in males and at least 80 cm in females had 44.53% sensitivity, 92.99% specificity, and 90.53% corrected classification.

When comparing area under the ROC curve of high BP, using WCM9080 as the gold standard, WCI9080, BMI23, and BMI25 had a larger area than that of WCM9080, with statistical significance (Table 5).

All proposed anthropometry indicators had a higher corrected classification than those of WCM9080. WCI9085 had the highest specificity (95.49%) and corrected classification (92.59%). BMI23 had the highest sensitivity (65.63%) (Table 6).

Discussion

Although high BP is rare in this population, this study used it as a health risk factor to determine the anthropometric indicator and cut off level among admission students because it was less expensive, less invasive, and more feasible for future intervention programs than using blood cholesterol, fasting blood sugar, or hemoglobin A1c. BP was reported as the key predictor of cardiovascular mortality over other components of metabolic syndrome among Korean and Japa-

Table 1. Relationship between anthropometry indicators and high blood pressure *

Anthropometry indicator**	Relative risk	95% confident limits	*p*
BMI ¬>= 23 versus < 23 kg/m^2	6.14	4.31 – 8.73	<0.0001
BMI >= 25 versus < 25 kg/m^2	9.03	6.48 – 12.60	<0.0001
WCI >= 90 cm in male and >= 80 cm in female versus lower values	8.20	5.96 – 11.31	<0.0001
WCM >= 90 cm in male and >= 80 cm in female versus lower values	2.90	2.07 – 4.05	<0.0001

* High blood pressure was defined as BPs of at least 140 mmHg and/or BPd of at least 90 mmHg,

** WCI waist circumference measurement at the superior iliac crest level; WCM waist circumference measurement at the midpoint between the lower costal margin and superior iliac crest

Table 2. Relationship between waist circumference measurements and high blood pressure

Blood pressure category* (mmHg)	Minimium (cm)	Median (cm)	Maximum (cm)	*p* **
WCM**				
Male				
High blood pressure	65.00	87.00	125.00	0.0001
Normal blood pressure	61.00	79.00	122.00	
Female				
High blood pressure	67.00	86.00	117.00	0.0001
Normal blood pressure	53.00	77.00	132.00	
WCI**				
Male				
High blood pressure	60.00	82.00	127.00	0.0001
Normal blood pressure	58.00	72.00	120.00	
Female				
High blood pressure	57.00	81.00	114.00	0.0001
Normal blood pressure	51.00	67.00	119.00	

* High blood pressure was defined as BPs of at least 140 mmHg and/or BPd of at least 90 mmHg
** Kruskal-Wallis test
*** WCM waist circumference measurement at the midpoint between the superior iliac crest and lower coastal margin
WCI waist circumference measurement at the superior iliac crest level

Table 3. Prevalence of high blood pressure among admission students by BMI cut off levels

BMI cut off levels kg/m^2	High	Normal	Total
Less than 18.0	3	431	434
Row %	0.7	99.3	100.0
18.0 - 22.9	41	1,450	1,491
Row %	2.7	97.3	100.0
23.0 - 24.9	9	248	257
Row %	3.5	96.5	100.0
25.0 - 26.9	14	115	129
Row %	10.9	89.1	100.0
27.0 – 61	61	152	213
Row %	28.6	71.4	1,00.0
Total	128	2,396	2,524
Row %	5.1	94.9	100.0

* High systolic BP of at least 140 and/or diastolic BP of at least 90
Normal systolic BP of less than 140 and diastolic BP of less than 90

Table 4. Receiver operating characteristic analysis of high blood pressure by waist circumference and body mass index

Anthroponmetry*	ROC area	Standard error	*p*	Sidak *p***
WCM(standard)	0.7326	0.0263		
WCI	0.7812	0.0237	0.0003	0.0005
BMI	0.7748	0.0240	0.0052	0.0103

*WCM waist circumference measurement at the mid-point between the superior iliac crest and lower coastal margin
WCI waist circumference measurement at the superior iliac crest level
BMI body mass index
** Sidak *p* of less than 0.05

Table 5. Receiver operating characteristic analysis of high blood pressure by the proposed cut off level of waist circumference and body mass index

Anthropon-metry*	ROC area	Standard error	*p*	Sidak *p***
WCM (standard)	0.6278	0.0226		
WCI9080	0.6837	0.0222	0.0000	0.0001
WCI9085	0.6689	0.0217	0.0153	0.0597
BMI23	0.7168	0.0216	0.0000	0.0000
BMI25	0.7334	0.0221	0.0000	0.0000

*WCM9080 WCM of at least 90 cm in males and at least 80 cm in females
WCI9080 WCI of at least 90 cm in males and at least 80 cm in females
WCI9085 WCI of at least 90 cm in males and at least 85 cm in females
BMI23 BMI of at least 23.0 kg/m^2
BMI25 BMI of at least 25.0 kg/m^2

Table 6. Sensitivity, specificity, and corrected classification of the proposed cut off levels from anthropometry indicators among the students

Anthropom-etry indicators	Sensitivity	Specificity	Classified
WCM9080 (standard)	53.13%	73.22%	72.20%
WCI9080	44.53%	92.99%	90.53%
WCI9085	38.28%	95.49%	92.59%
BMI23	65.63%	78.51%	77.86%
BMI25	58.59%	88.86%	87.33%

* WCM9080 WCM of at least 90 cm in males and at least 80 cm in females
WCI9080 WCI of at least 90 cm in males and at least 80 cm in females
WCI9085 WCI of at least 90 cm in males and at least 85 cm in females
BMI23 BMI of at least 23.0 kg/m^2
BMI25 BMI of at least 25.0 kg/m^2

nese university students [18]. Furthermore, BP and body type in the junior year could predict high blood pressure in the senior year [19]. The findings in this study showed that all cut off values of WCM, WCI, and BMI were associated with admission students having high BP. The higher the BMI revealed; the greater the prevalence of high BP in this population. Based on the findings of this study and health promotion programs in Thailand, the BMI cut off level for this population was defined as 23.00 kg/m^2 in both genders. The WHO suggested that the Asian population had different associations between health risks and BMI and body fat percentage than the European one. The current cut off levels underestimate health risks. The BMI cut off levels for observed risk varied from 22 kg/m^2 to 25 kg/m^2 [1]. According to the BMI cut off level of the WHO, only half of the students had an appropriate BMI and one fourth of them were overweight or obese [1]. Thaikruea *et al* reported that this cut off level in Thai people was associated with high cholesterol, high low-density-lipoprotein, low high-density-lipoprotein, high triglyceride, and a high total cholesterol to HDL ratio [16]. The BMI cut off level of 23 kg/m^2 should be used for prevention and health promotion.

The WCM and WCI of both male and female students with high BP had statistically higher significance than those of male and female students with normal BP. The WCI cut off level was at least 90.0 cm and 80.0 cm in male and female students, respectively, with moderate sensitivity, high specificity, and high corrected classification. The likelihood ratio of a positive test result was high as well. These cut off values were lower than those of the Chinese, which were 90.0 cm and 85.0 cm for males and females, respectively, and higher than those of Koreans [9,20]. The Korean health survey of a nationally representative sample showed that the cut off level for predicting metabolic risk factors was as low as 85.0 cm and 80.0 cm in men and women, respectively [8]. Another study in Korea found that the cut off level for discrimination of hypertension was 84.0 cm for men and 77.0 cm for women. These values were lower than those recommended by the WHO [9]. A recent study in Japan found an

optimal WC cut off value of 89.8 cm and 82.3 cm for men and women, respectively, which was lower than that currently recommended (women > 90.0 cm and men > 85.0 cm) [10]. This study used WCM9080 as a gold standard when comparing areas under the ROC curve of high BP with other anthropometric indicators. The results showed that BMI23 and WCI9080 had a significantly larger area than that of WCM9080. Other counties in Asia also re-defined the WC cut off level to lower values in their populations [10,11,14,21]. Thus, the WC measurement method should be of concern for health promotion and intervention programs. It is important also for trends over time, cohort studies and repeat measurements as well as the intervention programs [1,2,17].

This study suggests that WCI9080 be applied as screening for the risk of high BP and health promotion in admission students, due to the low prevalence of high BP, high specificity, high corrected classification, and high likelihood ratio of a positive test result. It is feasible also because WCI has been used for health screening in admission students and the measurement method is easier than that of WCM. Furthermore, WCI9080 does not conflict with values (90 cm in males/80 cm in females) of the government campaign. A study of 76 Thai women attending the 4th Regional Health Promotion Center compared different methods of WC measurement and found that the differences ranged from -10 to +16 cm. WC at the umbilical level was about three cm higher than that at the superior ileac crest level (Government report of the 4th Regional Health Promotion Center of the Thai Ministry of Public Health, August 2012). Thus, further study should be conducted to determine the cut off levels for screening health prevention and promotion programs. More cohort studies are needed to confirm or determine cut off levels of the BMI and WC combination for Thai adolescents. For national reference, this study recommends measuring at the umbilical level, due to its feasibility and easy understanding for health campaigns. However, an appropriate cut off level should be determined in the context of the Thai population [1]. Waist to height ratio is another measurement that should be explored.

There were some limitations of this study. The standard WCM cut off value, which is 90.0 cm in males and 80.0 cm in females, was measured at the midpoint between the lower costal margin and superior iliac crest. However, the Thai Ministry of Public Health refers to the umbilical level for easy understanding in its health education campaign. Therefore, this cut off level may not be appropriate, as sensitivities and specificities of WCI and BMI might be underestimated. It also might have a misclassification bias due to different staff members taking BP, WC, and BMI measurements. However, this study tried to reduce bias by training staff, using standard instruments, and calibrating the instruments. The advantages of this study were a very high participation rate, and health assessment carried out to the high standards of the Faculty of Medicine, CMU.

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เกณฑ์ที่เหมาะสมของการวัดรอบเอวสำหรับคัดกรองภาวะความดันโลหิตสูงในนักเรียนที่เข้ารับการศึกษาของมหาวิทยาลัยเชียงใหม่

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คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

ยังไม่มีเกณฑ์อย่างเป็นทางการสำหรับการวัดรอบเอวระดับขอบบนของกระดูกเชิงกราน superior iliac crest level (WCI) เพื่อคัดกรองสุขภาพในวัยรุ่นตอนปลายของไทย จึงทำการศึกษาเพื่อหา correlation ระหว่างการวัดแบบ WCI กับการวัดตรงจุดกึ่งกลางระหว่างชายโครงกับขอบบนของกระดูกเชิงกราน superior iliac crest (WCM) และ หาเกณฑ์ที่เหมาะสมของ WCI และดัชนีมวลกายสำหรับคัดกรองสุขภาพของนักเรียนจากภาคเหนือที่เข้ารับการศึกษาในมหาวิทยาลัยเชียงใหม่ ปี 2555 โดยทำการตรวจร่างกาย วัดรอบเอว แบบ WCI กับ WCM วัดดัชนีมวลกาย และวัดความดันโลหิต ผลพบว่า จากนักเรียนจำนวน 2525 ราย ที่วัด WCI กับ WCM นั้น ร้อยละ 59.50 เป็นเพศหญิง ค่า correlation WCI กับ WCM คือ 0.86 ร้อยละ 5.10 มีภาวะความดันโลหิตสูง ผลวิเคราะห์ Receiver Operating Characteristic analysis ROC ของภาวะความดันโลหิตสูง โดยใช้ WCM อย่างน้อย 90 ซม. ในชาย และ 80 ซม. ในหญิง (WCM9080) เป็นค่ามาตรฐานในการเปรียบเทียบ พบว่า WCI อย่างน้อย 90 ซม. ในชาย และ 80 ซม. ในหญิง (WCI9080) มีพื้นที่มากกว่า (0.6837) WCM9080 (0.6278) พบ WCI9080 มีค่าความไว ร้อยละ 44.53 ความจำเพาะร้อยละ 92.99 และจำแนกภาวะได้ถูกต้องร้อยละ 90.53 ถือเป็นเกณฑ์ที่ควรพิจารณา ทั้งนี้ควรมีการศึกษาติดตามในระยะยาวเพื่อยืนยันผล สำหรับการใช้อ้างอิงระดับประเทศ ขอแนะนำการวัดรอบเอวที่ระดับสะดือเพราะสะดวกและง่ายในการปฏิบัติ ทั้งนี้ควรหาเกณฑ์ตรวจคัดกรองที่เหมาะสมกับบริบทของคนไทยด้วย **เชียงใหม่เวชสาร 2556; 52(3-4):57-64.**

คำสำคัญ: รอบเอว คัดกรอง วัยรุ่นตอนปลาย ความดันโลหิต ประเทศไทย